THESIS

BREACHING ANALYSIS OF THE SPILLWAY FOR HUNZA RIVER LANDSLIDE DAM

7157

BY

MUHAMMAD WAJID IJAZ

(2009-PG-WRE-08)

FOR THE DEGREE OF

MASTER OF SCIENCE

IN

WATER RESOURCES ENGINEERING

CENTRE OF EXCELLENCE IN WATER RESOURCES ENGINEERING

University of Engineering and Technology, Lahore

2011

ABSTRACT

Landslides occur due to rock falling on account of slope failure caused by different hydrological, geological and weathering effects. Stability of such natural dams depends on volume of landslide mass, tectonic configuration and runoff rate from mountainous drainage network. Many landslides had occurred in Himalayan arc in Asia leading to landslide dams and most often causing storage behind them. A massive landslide dam having width of 2 km, height 124 m and crest length of 350 m was created due to settlement of 30 Mm^3 rockslide mass across Hunza River on 4th January 2010 near Attabad in Gilgit-Baltistan province of Northern Pakistan. More than 20 km long lake inundated Karakorum Highway, villages and several infrastructures existing on upstream.

A 20 m deep open channel spillway was excavated on saddle of this landslide dam with sill level at 2401 amsl for lowering the lake level as per consultant's recommendation it was visualized that landslide dam will breach after flow overtops the dam spillway. Spillway invert level was overtopped on 29th May 2010 and lake started draining and causing small channel bed erosion. However landslide dam did not breach as anticipated. Transportation of fines from channel bed exposed the coarser particles and further progressing erosion retarded due to channel armoring. This study has been under taken for modeling the erosion and finding possible options for breaching and likely failure of this natural dam. Hydraulic flow and sediment transport / erosion analysis was performed by using HEC-RAS model.

Physiographic data of landslide mass, particle size gradation curves, Hunza River flow rates, spillway water discharges and depth of erosions on temporal as well as spatial basis was obtained. Lake behind Attabad landslide dam was modeled by incorporating its storage elevation curve and hydraulically connected with spillway reach for routing the discharges by performing unsteady flow analysis in HEC-RAS. Particle size gradation curves data was initially used in sediment transport analysis

during calibration phase but none of particle size gradation curve data provided erosion results comparable to measured erosion parameters. A theoretical particle size gradation curve was adopted by keeping previous literature in view to represent the bulk of landslide infill and this generated a good match of modeled and measured erosion results. This calibrated and trained model was used for further breaching analysis.

The likelihood of landslide dam breaching / failure without any external intervention was also evaluated. This analysis was based on flow data for one year period. It was found that very small additional erosion could occur showing that landslide dam will not breach / fail under natural flow conditions; thus external intervention are required to breach the dam and drain the lake.

After accounting for different hydraulic, geologic and mechanical options for breaching the dam and draining the lake in a safer mode a hydraulics oriented case was formulated. This option include: (1) plug the mouth of spillway with fuse plug / stop logs / check dam / bulk head of 15 $\pm$ m height, (2) let the lake water level to rise behind this dam from river inflows, (3) breaching the check dam instantaneously by controlled blasting, (4) generate instantaneous high discharges from the stored water and rout it through spillway in order to restart the erosion by breaking up armor layer of coarser particles. The modeling analysis demonstrated that by introducing repeatedly check dam and subsequent controlled breaching can effectively lower the dam height upto 70 m. Further erosion generation become less efficient due to decreased generation of high discharges from small storage volume resulting from same height check dams.

It is concluded from this study that Attabad landslide dam is stable without any external intervention under natural flow conditions. It is also concluded that with repeated introducing and blasting the check dam can lower the dam height upto 50 m and remaining part of dam may be accepted or else has to be remove with mechanical or blasting source. It is recommended that check dam option should employ for safe drainage of lake and controlled blasting for boulder removal. For more authentic erosion

results additional particle gradation and allied geotechnical data should be used in modeling.